Decarbonizing and Electrifying DHW Using Commercial-Scale CO2 Heat Pumps

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QAHV Heat Pump Water Heater

• Utilizes Natural refrigerant
  • CO₂
  • Global Warming Potential of 1

• High efficiency
  • COP up to 4.52

• High Temp Hot water
  • Up to 176°F
Low Ambient Temperature Operation

- Operable at low outdoor temperatures
  - Down to -13°F (with capacity rating)
  - Down to -35°F (without capacity rating)
- 100% heating capacity at 36°F
- 50% heating capacity at -13°F
Variable Capacity

• 3 Capacity Settings
  • 136,485 BTU/hr. / 40kW
  • 170,607 BTU/hr. / 50kW
  • 204,728 BTU/hr. / 60kW

• Up to 16 units can be piped in parallel

• Maximum system size
  • 2,183,770 BTU/Hr. / 640kW
Refrigerant to Water Heat Exchanger

Twisted Spiral Gas cooler
Patented technology
Double Wall construction
6 per QAHV
Flash Injection Technology

**Stable Heating Capacity even at low temperature**

- Full heating capacity even at 36°F/2°C
- Operable as low as -13°F/-25°C

High performance even at low outdoor temp.

Highly efficient inverter-driven CO2 scroll compressor

![Graph showing stable heating capacity](image)

![Diagram of injection circuit](image)
Why CO₂

Environmentally friendly
Global Warming Potential of 1
Ozone depletion potential of 0
Nonflammable
Nontoxic
High pressure/temperature refrigerant
Excellent Low Ambient Performance
Highly efficient
CO$_2$ and the Trans-critical cycle

- Higher Pressure compared to R134a
- Refrigerant remains in a vapor state during the heating cycle
- High heat transfer coefficients
- Higher volumetric capacity

![Diagram of CO$_2$ and R134a cycles with water heating points highlighted.](image-url)
CO2 Heat Pump System Schematic

Primary Side

Secondary Side + Storage

Re-circulation + Swing Tank
Basic System Schematic – Multiple Heat Pumps

COOL EXHAUST AIR

SOURCE AIR

FLOW THROUGH EXPANSION/BUFFER TANK

PUMP

HEAT EXCHANGER

FLOW THROUGH EXPANSION/BUFFER TANK

MITSUBISHI QAHV

PUMP

THERMAL STORAGE TANKS

SWING TANK

CITY WATER CONNECTION

PRIMARY STORAGE EXPANSION TANK

HW RETURN CONNECTION

HW SUPPLY CONNECTION

ELECTRONIC MIXING VALVE
Commercial CO2 System Components

Installation Complexity
Mistakes
Labor
Cost
Skid Approach
Intermediary Skid

- Factory assembled
- Secondary Pump
- Secondary HEX
- Buffer Tank
- Expansion Tank
- Key Valves
- Controls
- Fits through standard doorway

- Reduced on-site complexity
- Less labor required
- Quality - works 1st time
Unique Tank Designs

• Engineered storage tank solutions to maximize the efficiency of the system
• Patent Pending baffle design promotes reduced velocity in both directions
Tank Stratification – 95% Volume Utilization
Design Selection Software

Outdoor Air Temperatures:
- Location: New York, New York City
- Heating Dry Bulb: 12.0°F
- Heating Wet Bulb: 10.8°F
- Heating Rel. Humidity: 72.8%
- Cooling Dry Bulb: 80.0°F
- Cooling Wet Bulb: 67.0°F
- Cooling Rel. Humidity: 51.8%

Indoor Entering Coil Temperatures:
- Heating Dry Bulb: 70.0°F
- Cooling Dry Bulb: 90.0°F
- Cooling Wet Bulb: 73.0°F
- Cooling Rel. Humidity: 60%
Selection Software System Sizing

Instructions: use Ecotope Ecosizer tool to establish system requirements
https://ecosizer.ecotope.com/sizer/size
Ecosizer Heat Pump and Tank Sizing Tool

User Friendly sizing tool developed by Ecotope
Simple input options for the user
Quick results with the ability to edit and customize the selection

Tank Volume
1,287.00 Gallons

Swing Tank Volume
120 - 300 Gallons

CA Title 24 Swing Tank Volume
480 Gallons

Heating Capacity
283.80 kBTU/hr

Swing Resistance Element
31.5 kW · 107.5 kBTU/hr

Primary Sizing Curve

Recommended minimum heating capacity shown below is the minimum needed average output capacity of the selected equipment at the design cold air temperature in your climate zone. Note that you must also account for manufacturer specific defrost penalty.
Selection Software Inputs
Selection Software System Schematic
Controls

• Cohesive controls package required
  • BACnet connectivity
  • Load shifting / demand response
  • CTA2045 compatible

• Monitoring of 3rd party devices

• COP Monitoring of System

• Install wizard
Bayview Tower - QAHV Retrofit Project

- 100-unit multifamily building
- Pre-retrofit monitoring
- Packaged skid delivered to site
- Demand response controls through CTA-2045
- Measurement and Verification System
Pre-retrofit Monitoring

- 3,600 Gal/day peak load
- 3,150 Gal/day avg load
- ~20 gal/day/person
- 80 W/apt recirculation load
- Recirculation approximately 40% of total load
Packaged Skid
Skid installation
Piping Design

Electric Resistance Operation

Heat Pump Operation
Bayview Tower – Energy Use Comparison

• Previous System
  • 102kW Power Input (6 Rheem Commercial Water Heaters)

• Heat20 System
  • 14kW Power Input (Plus cycling of 4 water heaters during low load/overnight operation)
  • 2 Rheem water heaters removed entirely
  • Estimated energy reduction of 136,875 kWh/year or 40%
  • Estimated annual cost savings of $15,000 based upon $0.11 kWh electricity rate
Hotel Marcel New Haven Connecticut – Historic Pirelli Building

- 1\textsuperscript{st} Net Zero Hotel in the U.S.
- 110,000 sq. ft. retrofit project
- 165 guest rooms
- 60% more energy efficient than code requirements
- All electric building
- 3 QAHV heat pump units installed
- 12 Tesla Superchargers
- Over 1000 photovoltaic panels
- VRF systems for cooling/heating
Key Considerations

• Engineered solutions required - not just adding heat pump units

• System sizing is critical to operation and efficiency – consider load shifting when sizing system

• Increased storage tank volume for retrofit applications

• Where will the new storage tanks be located?

• Is the existing power supply adequate for the new heat pump loads

• Follow manufacturers recommendations for system design
Thank you!